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Hereditary and Environmental Factors in Musical Ability

THE AIM OF the investigation to be described was to study how far musical ability depends on heredity or environment by comparing parents with children, and monozygotic with fraternal twins.

In most earlier studies musical talent had been assessed on the basis of reputation or of questionnaire data on musical activities. Though satisfactory tests of musical ability had existed since the 1930s, little attempt had been made to apply them in genetic studies. A detailed account of the literature can be found in the writer's thesis (Shuter, 1964).

Pedigree and Questionnaire Studies

Galton (1869) studied the genealogy of 120 eminent and original musicians. But only twenty-six of these had had eminent kinsmen, not all of whom were musicians. He included nine members of the Bach family—surely the most remarkable of all the musical families in history. According to Shull (1948), of fifty-five male Bachs in six generations, forty-eight were musicians and only seven had no known musical gifts.

Biographical material tends to be incomplete, however, as Feis (1910) found. He attempted to study the ancestors and descendants of 285 famous musicians, but information on maternal lines was especially difficult to obtain. Moreover, many of the musicians failed to produce children.

An investigation of contemporary musicians and students at the Juilliard Graduate School of Music was carried out by Scheinfeld for the first edition of *You and Heredity*. His virtuosi group in the following table included such outstanding performers as Yehudi Menuhin and Artur Rubinstein.

TABLE 1

Approximate percentage of relatives with some degree of talent

Group	No. in Group	Percentage for		
		Fathers	Mothers	Siblings
Virtuosi	37	75	50	50
Opera singers	36	67		40
Students of music	50	58	74	70

An analysis of the incidence of talent in the three groups showed that where both parents had musical talent, more than 70 per cent of the brothers and sisters (in addition to the individual reporting) also had talent. Where only one parent was talented, there was talent in 60 per cent of the siblings. Where neither parent was talented, only 15 per cent of the brothers and sisters had talent.

Scheinfeld concluded that a multiple-gene mechanism would be needed to account for these ratios, and the simplest one which might fit the requirements would be, at the very least, two different dominant genes. Such a theory would help to explain the sudden appearance of a highly talented individual in an apparently unmusical family—Scheinfeld quotes the example of Toscanini. Whether great musicians differ from those of lesser talent in possessing special "talent" genes is, however, open to question.

Hurst (1912) seems to have been the first person to apply Mendel's laws to an unselected population. From his observations of parents and children in a Leicestershire industrial village he concluded that musical ability was a recessive trait. Lack of musical aptitude might be due, he thought, to an inhibitory factor preventing the expression of the musical capacity which is hypostatically present in everyone. Do the tone

deaf, he wondered, suffer from a double dose of the inhibitory factor?

In the 1920s several Continental workers sought to study the inheritance of musical ability, as assessed from questionnaire data. Mjoen (1926) graded his subjects' musical ability on a scale from 0 to 10. In the following table those described as P (Poor) were rated between 0 and 2; at most, their ability was limited to being able to recognize a tune. The M (Musical) group ranged from those who knew when they sang out of tune (3) to being able to improvise a second part (7). The S (Superior) subjects were graded 8 to 10 and were, at the least, able to play by ear, while the most talented of all could compose, and play several instruments.

TABLE 2

Percentages of children in grades of talent born to parents of various combinations of talent

Parents	Number of parents	Number of children	% of children		
			S	M	P
S×S	7	23	72	28	0
S×M	40	175	60	34	6
S×P	9	34	26	37	37
M×M	30	113	39	49	12
M×P	21	75	7	40	53
P×P	7	22	0	10	90

Thus, the higher the average talent of the parents, the higher the average talent of the children is likely to be. The environmentalist might object that the musical environment provided by parents is liable to vary roughly with their own talent or lack of talent. Mjoen, however, also presents evidence that where both parents are musical (grade 5 or above), the proportion of musical children corresponds to the number of gifted grandparents, and concludes that it is the quality of the stock rather than that of the parents which is decisive.

Haecker and Ziehen found that the chance that a child will be very musical is 86 per cent where both parents are talented, about 60 per cent when one parent is musical, and about 25 per cent when both parents are unmusical. Remarkably similar percentages were obtained by Heymans and Wiersma (see Revesz, 1953).

Such questionnaire surveys depend, of course, on the accuracy of the replies. Where instrumental playing is taken into account, they do

less than justice to individuals who have lacked the opportunity to learn to play.

Studies based on Testing

With the development of musical ability tests more accurate means of assessing aptitude became available. The first standardized tests to be published were the *Seashore Measures of Musical Talent* (1919). These were intended to measure capacity to perceive fine differences in pitch, time, intensity etc. and to judge which tone in a sequence had been altered on a second playing. Their relevance to functional musical ability, such as required for success in learning to play an instrument, has been repeatedly questioned. The pitch and tonal memory tests are probably the best from this point of view.

Since 1930 tests based on musical material have been developed, some of which do provide satisfactory estimates of musical potentiality. Perhaps the best established and most comprehensive battery is the *Wing Tests of Musical Intelligence*. Three of the seven tests are concerned with ear acuity: how many notes in a chord? Have two chords been repeated exactly, or has one note moved up or down? Which note of a melody has been changed on a second playing? Four are tests of appreciation, of rhythm, harmony, intensity and phrasing. In each test a tune is repeated in identical or altered style. The subject has to decide whether the second version is the same or not, and, if different, which is the better rendition.

Such tests do not, of course, provide information as regards the muscular side of performance.

A pioneer genetic study in which the Seashore Measures were used was undertaken by Stanton (1922). She tested eighty-five members of the families of six well-known American musicians and drew up talent profiles for each family. Her results seem to confirm that the child from musical stock has a better chance of being musical, but her tables are difficult to interpret, since no statistical analysis is applied.

Seashore's pitch, loudness and rhythm tests and Wing's pitch and memory tests were included in the Hereditary Abilities Study (Vandenberg, 1962). Some thirty-three pairs of MZ and

forty-three pairs of DZ twins were studied. Significant differences between the two types of twin were found only in the case of the rhythm and of the memory tests. The heritability indices, calculated with Clark's formula, were as follows:

Seashore	Pitch	0.00
	Loudness	0.44
	Rhythm	0.52
Wing	Pitch	0.12
	Memory	0.42

The Seashore rhythm test is of doubtful reliability, but other evidence suggests that rhythmic capacities are especially resistant to environmental influences. It is surprising that the two pitch tests should apparently be so little subject to hereditary control. Vandenberg himself suggests that it may be that only the exceptional talent of the great composers and musicians has an hereditary factor. He adds that possibly defects rather than proficiencies are more properly the concern of hereditary studies.

An interesting investigation of tone deafness was carried out at University College, London by Kalmus and Fry. They developed a distorted tune test consisting of a few phrases of twenty-five well-known tunes. In one version the tune was played correctly and in the other the melody was distorted by the insertion of several blatantly wrong notes, the rhythm remaining unchanged. The subjects were asked to decide whether the tunes were played rightly or wrongly. The test discriminated efficiently between 95 per cent of some 1200 adult and adolescent subjects considered normal and 5 per cent regarded as tone deaf (Fry, 1948). Performance of Seashore's memory test was invariably poor among the tone deaf, who were also weak on a pitch discrimination test. The tone deafness appeared frequently to segregate in families and siblings in ratios indicating that it might be caused by a single gene, possibly a dominant. But Kalmus (1952) is cautious in his conclusions and believes that there may be several types of tone deafness and that it is by no means independent of upbringing.

Wyatt (1945) provided ample evidence that really efficient individual coaching could significantly improve pitch discrimination. Practice at singing back notes and phrases can lead to a

lasting improvement among children aged three to five (Updegraff, Heileger and Learned, 1938). How far-reaching would be the effects of a long-term programme of such training is not known. Evidence is, however, available on the influence on test results of a normal amount of exposure to music. Most test authors have tried to produce tests that would be as little affected by previous experience as possible. Wide differences of ability certainly exist among individuals brought up in musically similar environments. In one case a marked difference between two sisters was found even at the early age of eighteen months; their subsequent careers confirmed the difference. Allowing for maturation, scores remain reasonably constant and unaffected by whether the child has commenced studying an instrument or given up music lessons. Again, little real differences in scores are found with groups varying e.g. in sex, race, or cultural background (Wing, 1948; Drake, 1957; Bentley, 1966).

It has been pointed out that many of these results refer to children who may have already passed the stage where training could affect performance of the tests. Holmstrom (1963) obtained evidence that children of eight who come from musically good homes make significantly better scores than those from musically poor homes. This does not, of course, disprove that heredity is a factor.

The Parent-Child Study

Fifty-four pupils of a mixed grammar school and thirteen from a grammar school for girls, both in the Home Counties, and seventy-eight of their parents were tested with the Wing battery. Data on instrumental playing, music lessons, concert-going and home listening were collected by questionnaires.

It would have been desirable to include parents and children at all ability levels. But a volunteer group tends to become a self-selected one, since adults are more likely to attend if they themselves are musical, or have some interest in music, or feel that their children may show talent. The scores showed that the parents were in fact rather above average in musical ability. Many of the children were highly

talented and had enjoyed superior opportunities to have music lessons and to listen to good music. But even with this select group, the midparental-child* and the sibling correlations (Table 3) were very similar to the 0.5 "typically" reported in studies of intelligence (see Vernon, 1960). The low correlation of 0.290 for the full sample rose to 0.364 when the results from the girls' school where the self-selection effects were particularly strong were omitted. With a more representative sample, a still higher correlation might have been obtained.

TABLE 3
Correlations on the Wing Test

	Number	Correlation coefficient
Midparent-child	25	0.475
Each parent-child	100	0.290
Father-child	25	0.627
Mother-child	25	0.258
Higher scoring parent-child	25	0.394
Father-mother	25	0.331
Siblings	14	0.496

Considering that an interest in amateur music-making might lead to meeting a marriage partner of similar tastes, one might have expected a fair degree of assortative mating among this sample of parents. The figure obtained, 0.331, is quite low, compared with the correlations ranging from 0.3 to 0.7 reported with married and engaged couples on height, intelligence and a wide variety of other traits (see Cattell, 1950).

Again, any effect of dominance, as shown by musical ability being transmitted by the more talented parent, did not appear prominently in the results.

The striking difference between the father-child and mother-child correlation was difficult to explain. Boys make roughly the same scores as girls on musical aptitude tests. It is therefore hard to see how a sex-linked mechanism could be involved in the transmission of musical capacity. The data from the parents' questionnaires on the amount of playing, the music lessons they had received, and their listening habits, were carefully examined for an environmental explanation. However, even with these older children, it seemed to be the mother,

rather than the father, who set the musical environment. Perhaps some subtle selection mechanism was at work—conceivably, men may be more likely to volunteer to be tested if they suspect that their offspring resemble themselves! In any case, the number of cases where both parents could be tested was only twenty-five, so the results can be considered no more than suggestive.

The data from the parents' questionnaires were also compared with a total index of the children's musical level. This was obtained by adding, to their Wing scores, a mark for musical knowledge, a listening score and a combined score for playing and music lessons. Parental playing and music lessons were the only variables which showed a highly significant (p less than 0.01) association with the children's musical level. This may be regarded as an example of the interaction of hereditary and environmental factors, but could be interpreted as supporting either side. Thus, it could be argued that those parents who had received music lessons and kept up their playing were themselves musically talented and that the children had inherited their gifts. The adults' Wing scores did seem to show, broadly speaking, a positive association with the amount of training they had received. On the other hand, the environmentalist would say that the parents' playing had contributed to raising the children's musical level and that parents who have themselves learned an instrument are more likely to encourage their children to learn to play. The correlation between the children's Wing scores and their score for lessons and playing combined was quite high, 0.654. This might well have been partly due to the weaker children making slow progress and giving up their lessons. If the subjects had been drawn from a population where few had enjoyed opportunities to learn music, more decisive results might have been obtained.

The Twin Study

1. *Twins Brought up Together.* Fifty pairs of twins, with ages ranging from nine to sixteen, from some twenty schools were tested with the Wing tests. They were classified as identical or fraternal by general impression and by

* The parents' scores were averaged; in the eight cases of siblings, the average of both children was used.

HEREDITARY AND ENVIRONMENTAL FACTORS IN MUSICAL ABILITY

careful inspection. Questioning the twins proved helpful in clearing up some cases of doubt; some superficially alike pairs indignantly denied that they were ever mistaken for one another by relatives or teachers. The proportion of MZ to DZ twins (40:60) was higher than the proportion in the general population (28:72 according to the General Register Office statistics). This is partly because the writer tried to obtain fairly equal numbers of each type.

The smaller differences are somewhat more frequent among the MZ twins and the larger among the DZ groups. The extent of intrapair differences was compared with the twins' attitudes to music, amount of training and of listening, age and musical level. No consistently significant relationships emerged. Differences were slightly greater among the younger, as opposed to the older, pairs. With both types of twin there seemed to be a certain tendency for the

TABLE 4
Distribution of Musical Quotient Intra-pair Differences

MQ Points Difference	IDENTICAL				FRATERNAL				
	Children		Adults		Children			Adults	
	Boys	Girls	Men	Women	Boys	Girls	Mixed	Men	Women
0-4	4	2	2		1	3	1	1	
5-9	1	2		1		2	1		
10-14	2	2	2		3	2	2		
15-19		1	1	1	2	1	4		1
20-24	3	2		1	1				
25-29					2	2	1	1	
30-34		1				1			
35-39									
40-44									
Over 45						1			
Totals	10	10	5	3	9	12	9	2	1

Also, many boy-girl pairs would be at different schools and likely to be missed. It is usually considered better to exclude opposite-sexed pairs, but, as will be seen, those in the present sample were not unduly dissimilar in their musical ability.

In addition to the child twins, Wing scores of eleven pairs of young adults who were being studied by the M.R.C. Psychiatric Genetics Research Unit for another purpose were obtained.

If the sample of parents and children was unrepresentative in being more talented than average, most of the twins were atypical in being well below average in musical aptitude. In particular, the appreciation tests may have been unduly affected in some cases by guessing. The results reported below therefore are based only on the three ear acuity tests. The Wing scores were converted into Musical Quotients (MQs) by Wing's formula (Wing, 1960). The distribution of intra-pair differences for each class of twin is shown in Table 4.

smaller differences to be found among the lower scorers. This might mean that the weaker the ear for music, the less responsive will the individual be to any environmental stimulation, or perhaps the more marked the degree of inherited defect, the harder it is to modify. The majority of the twins had never had music lessons (apart from class lessons at school) and only very few ever attended concerts or listened to classical music at home. Among the identical twins, if one had received music lessons, so had the other. A difference of 23 MQ points was found among a highly talented pair of blind boy twins, judged to be identical. Both had been studying the piano for four to five years and did a good deal of practice. On the other hand, the two pairs of identical girl twins with the most discordant scores (differences of 23 and 33) had never had music lessons. Among the fraternal twins, the larger differences were found among those who were having lessons and who played for about equal periods, as opposed to those who were similar in not playing at all. But the number

was too small to be conclusive as to whether or not the training might have increased the differences.

With one DZ pair, the MQ of one twin was 88 points lower than that of her co-twin. Both had failed to record their answers to the first test in the right place. As their MQs were based only on their performance of tests 2 and 3, it seemed better to omit such an extreme result from the correlation calculations, in the absence

some connection with the higher proportion of boys classified by their teachers as tone deaf. A survey of over 16,500 schoolchildren by Bentley (1954, 1957) found that, at the age of twelve, 7 per cent of boys, but only 1 per cent of girls, are considered "monotones". Bentley himself was inclined to believe that this 4 per cent of individuals may be the same 5 per cent of the adult population who are tone deaf according to the findings of Kalmus and Fry.

TABLE 5

Intra-pair Correlations of Musical Quotients

MZ (n. in pairs)	<i>r</i>	DZ (n. in pairs)	<i>r</i>	<i>h</i> ²
20 child	0.838	20 child (like sexed)	0.719	0.423
20 child+8 adult	0.794	29 child+3 adult	0.721	0.262
10 boy	0.899	9 boy	0.734	0.617

of verification by retesting. *h*² was calculated using Holzinger's formula.*

The extent of the MZ/DZ contrast (Table 5) was much less than has been reported on intelligence (see Vernon, 1960). It would be unwise to conclude, however, that hereditary factors are less important in musical ability. The numbers were rather too small for correlations to be really stable; the level of difficulty of the tests may affect correlations (cf. Vandenberg, 1962); and with such unmusical children the Wing tests may well give less reliable results than the best intelligence tests.

Environmental factors, as far as they could be assessed from the questionnaires, did not seem to account for the high *h*² among the boy twins considered separately. There might be

However, why some monotones outgrow or overcome their deficiency before the age of twelve, while others do not, would require investigation.

The scores for the 30-itemed pitch and memory tests were not intended by Wing to be used separately from the other tests. However, it seemed worth while trying to see whether Vandenberg's results could be verified or disproved. The intrapair correlation on pitch for the twenty pairs of DZ child twins was higher, 0.767, than that for the twenty pairs of MZ twins, 0.558. On memory, however, with age partialled out, the intrapair correlation was 0.766 with the MZ group and 0.500 with the DZ group. *h*² as calculated with Holzinger's formula was 0.532. If Clark's formula was used, as in Vandenberg's study, the *h*² rose to 0.642. The evidence in the literature on the heritability of pitch discrimination is somewhat contradictory (see Shuter, 1964, pp. 193-5). One might have expected that, if any difference existed at all, pitch would have been more highly heritable than musical memory.

2. *Twins Brought up Apart.* Thanks to the kindness of Mr. James Shields of the M.R.C. Genetics Research Unit, five pairs of identical twins brought up apart, who had earlier been studied by him, were tested. The pseudonyms used by Shields in his book (1962) have been adopted here.

* *h*² is a statistic devised by Holzinger as a measure of the proportion of the variance of a trait in a given population that is due to heredity as opposed to environment (Newman, Freeman and Holzinger, 1937). It is useful as an expression of the estimated importance of genetic control, but has been criticized because it assumes that the environments of MZ and DZ twins can be regarded as equivalent and does not take into account any interaction between heredity and environment. Holzinger's formula is

$$h^2 = \frac{r_{MZ} - r_{DZ}}{1 - r_{DZ}}$$

where *r* is the intra-class correlation for MZ or DZ twins. Vandenberg (1962) preferred to use Clark's formula, which divides the variance of the DZ twins minus the variance of the MZ twins by the variance of the DZ twins.

The intrapair differences in Wing raw scores* were as follows: 2, 2, 12, 15 and 20.

One of the pairs whose scores differed by only 2 points had rather similar musical backgrounds: both claimed to be interested in music; both had one or two years of piano lessons during childhood. Both of the other pair of twins with a difference of only 2 points had grown up in families where other members of the family played in brass bands. But while Francis had actually played the cornet in a band for twenty-four years, Foster had not had the opportunity of learning to play till only two months before he was tested (at the age of thirty-eight). Their scores were very close to the average on Wing's norms. The pattern of subtest results was very similar.

The twins with the difference of 12 marks were aged fifty-seven when tested. The lower score was made by Jim, the twin who was more interested in music than his co-twin and who had the more sophisticated tastes. He liked ballet music and Tchaikovsky: his brother preferred Strauss.

Jacqueline, whose Wing score was just above average while her sister's was 15 points less, had enjoyed a much superior musical background as a child. There was constant music-making at home; she had piano lessons for seven years and later conducted a Townswomen's Guild choir. No one in Beryl's home played and she had never had music lessons.

The largest difference was found with a pair of female twins, tested when aged forty-three. Their father played the piano and had gained diplomas for music. Olive, brought up by her own parents, had two years of piano lessons. From the age of fourteen, she listened to light classical music every evening. Madge was brought up by an uncle and aunt who encouraged her to become a piano teacher. She held an A.T.C.L. diploma, but at the time of testing, had given up music teaching. Both twins scored well above the average and some of Olive's subtest scores were very similar to Madge's. They had similar tastes in music.

Conclusions

The genetic factors that emerged from the present investigation are less strong than those found in studies of intelligence, probably because of the musical level of the subjects that could be tested.

The general conclusion to be drawn from this and other studies reported in the literature is that genetic components do impose an upper limit to achievement and speed of learning in music. How much less than maximum attainment is reached in an unstimulating environment is difficult to determine. The possibility of improving musical ability, as measured by the Wing tests, is suggested by the difference of 20 marks between a pair of MZ twins brought up apart. But this difference occurred where one twin had enjoyed the opportunity of training up to piano teaching diploma standard. It might, moreover, be only among persons with high initial endowment that differences of training could produce such a difference in test performance. Also, the more experienced twin may have felt more confident about tackling the tests. Sensibly used, tests such as the Wing have considerable prognostic value in estimating future success with music.

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* Difference between raw scores=roughly half the difference between MQ points.

THE EUGENICS REVIEW

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